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(54) **METHOD FOR MEASURING ELECTRIC POTENTIAL DIFFERENCE**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G01R 27/14	(2006.01)
G01R 19/10	(2006.01)
B82Y 30/00	(2011.01)
G01R 29/14	(2006.01)

(52) **U.S. Cl.**
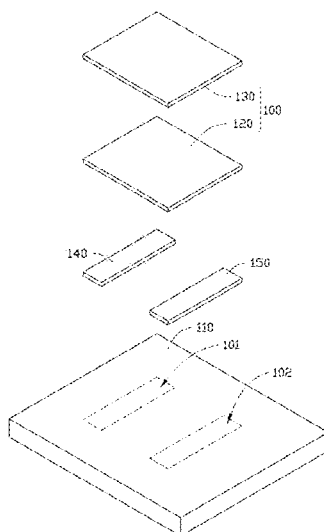CPC *G01R 19/10* (2013.01); *B82Y 30/00* (2013.01); *G01R 29/14* (2013.01)

(58) **Field of Classification Search**
CPC G01R 19/10; G01R 29/14; B82Y 30/00
See application file for complete search history.

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(57) **ABSTRACT**

A method for measuring electric potential difference comprises following steps. A carbon nanotube composite layer is located on an object and electrically connected to a first region and a second region spaced from each other in the object, wherein an unknown electric potential difference U exists between the first region and the second region. Characteristic band frequency value Y* of Raman-spectra of the carbon nanotube composite layer under the unknown electric potential difference U is measured. A relationship between the characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU of the carbon nanotube composite layer is obtained. Value of unknown electric potential difference U is obtained through the relationship between the characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU.
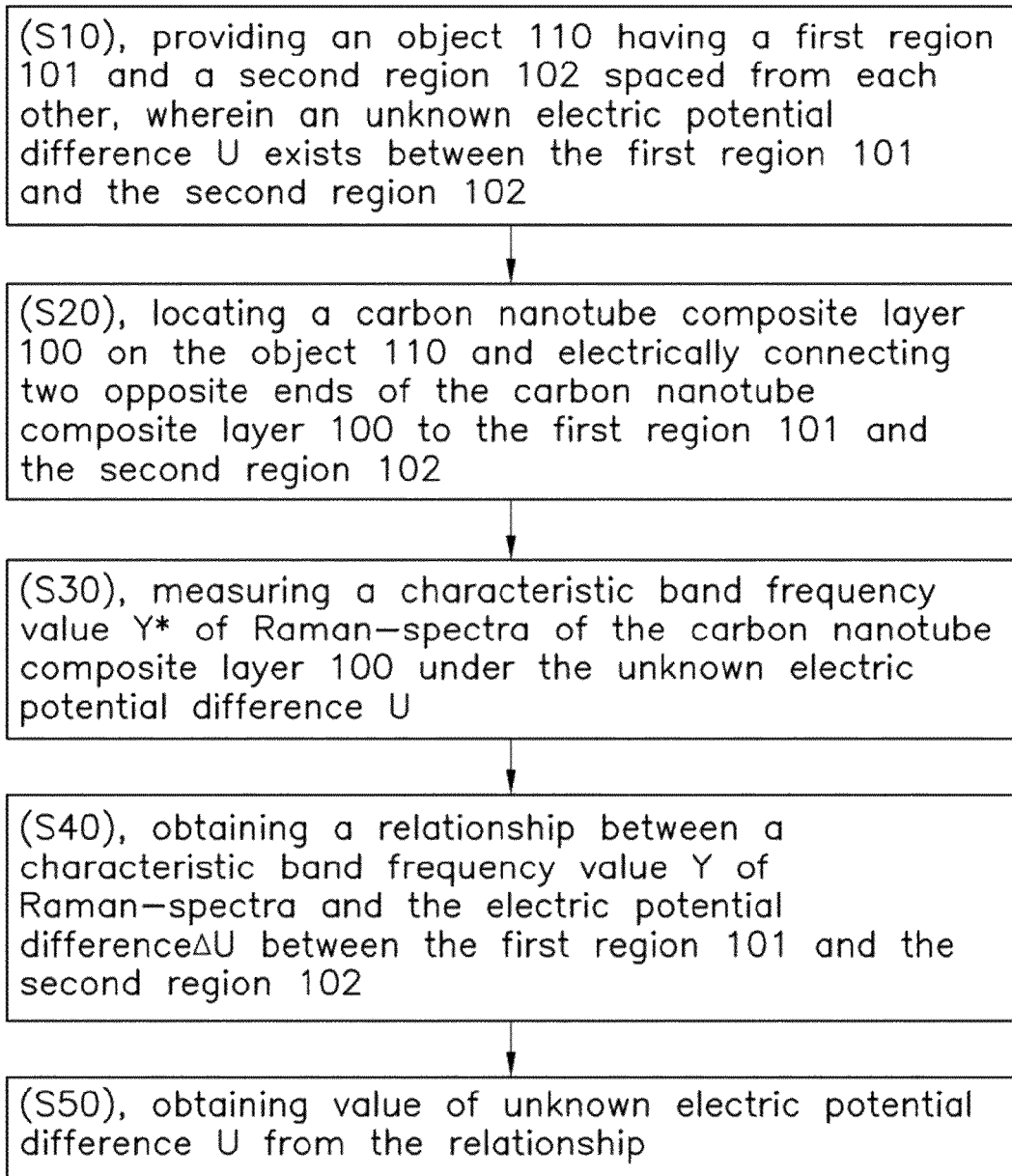
19 Claims, 17 Drawing Sheets

(S10), providing an object 110 having a first region 101 and a second region 102 spaced from each other, wherein an unknown electric potential difference U exists between the first region 101 and the second region 102

(S20), locating a carbon nanotube composite layer 100 on the object 110 and electrically connecting two opposite ends of the carbon nanotube composite layer 100 to the first region 101 and the second region 102

(S30), measuring a characteristic band frequency value Y* of Raman—spectra of the carbon nanotube composite layer 100 under the unknown electric potential difference U

(S40), obtaining a relationship between a characteristic band frequency value Y of Raman—spectra and the electric potential difference ΔU between the first region 101 and the second region 102

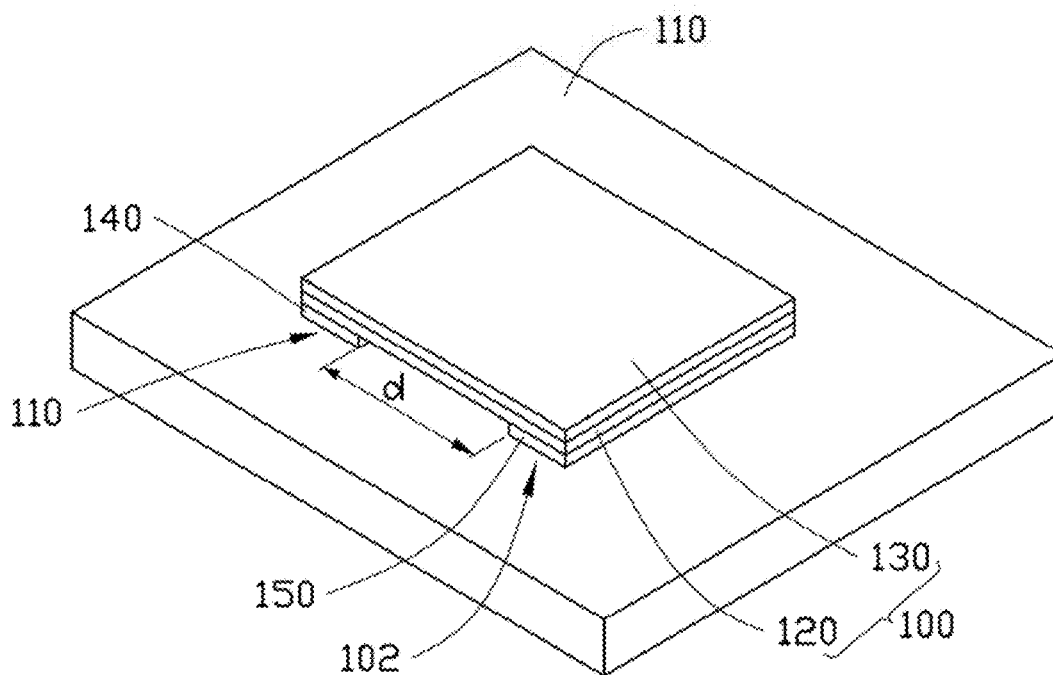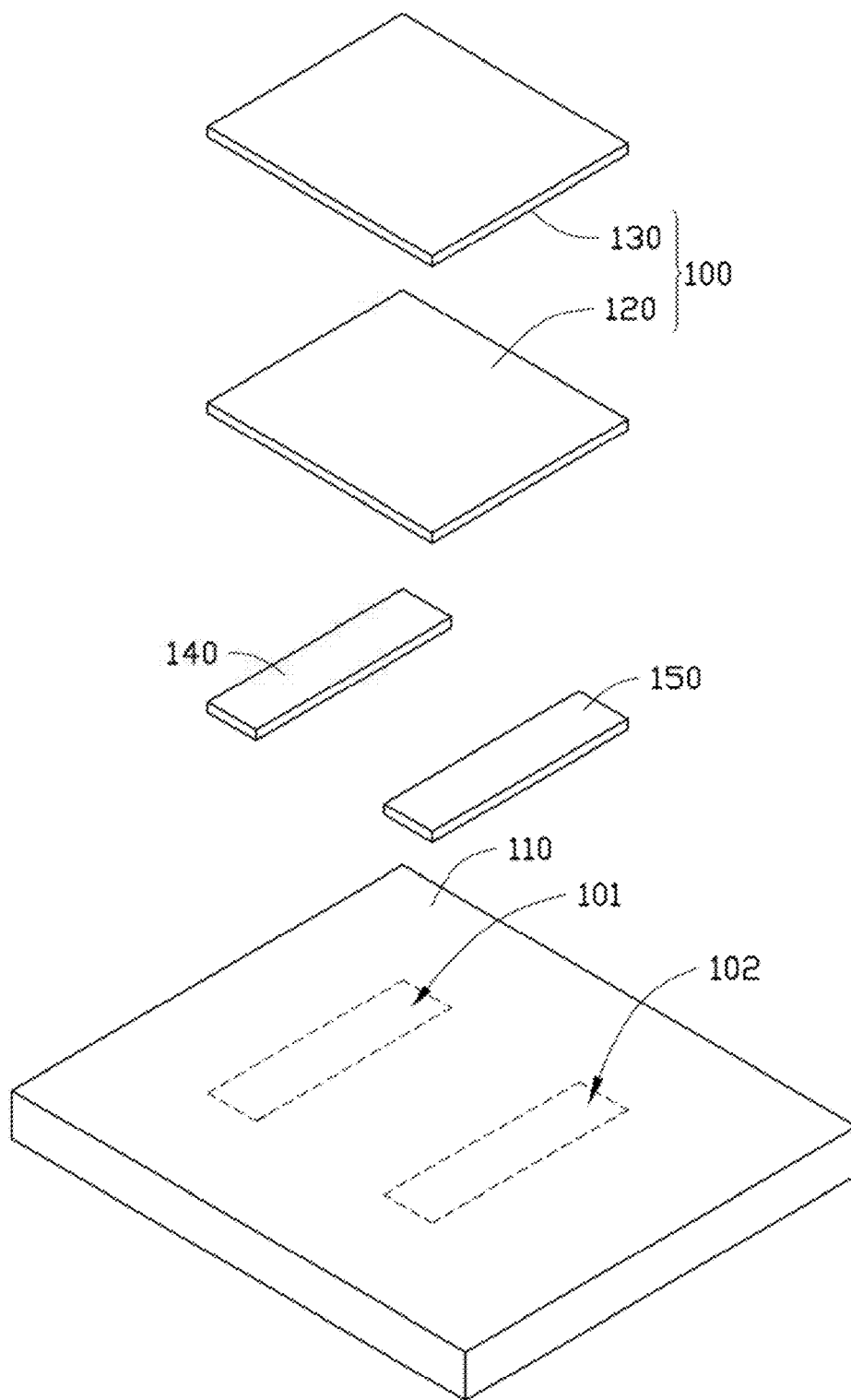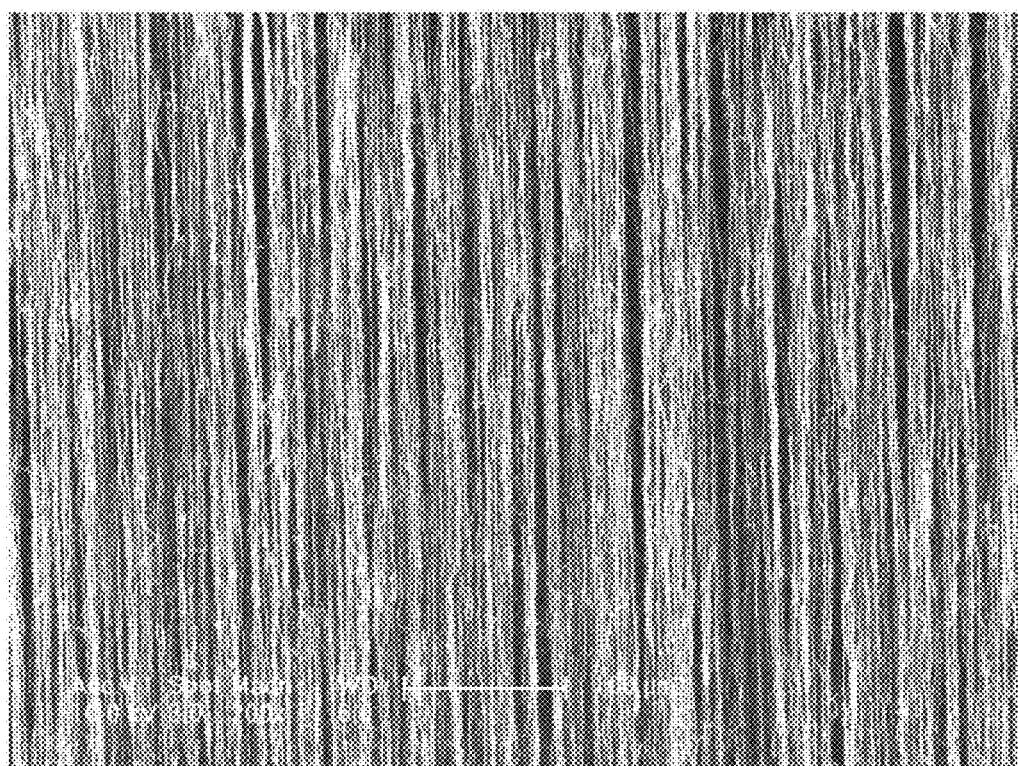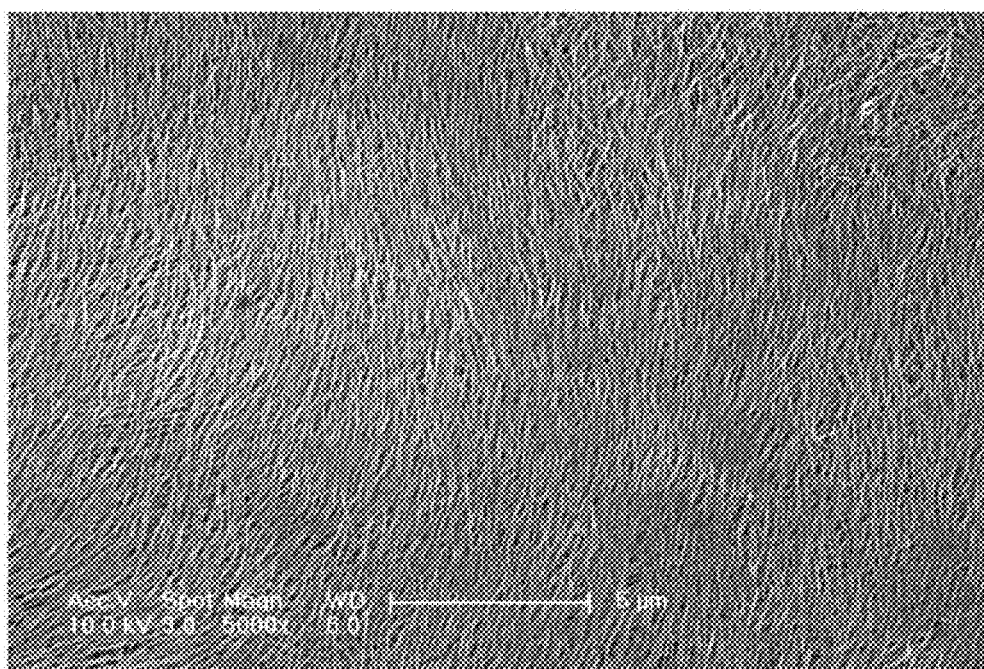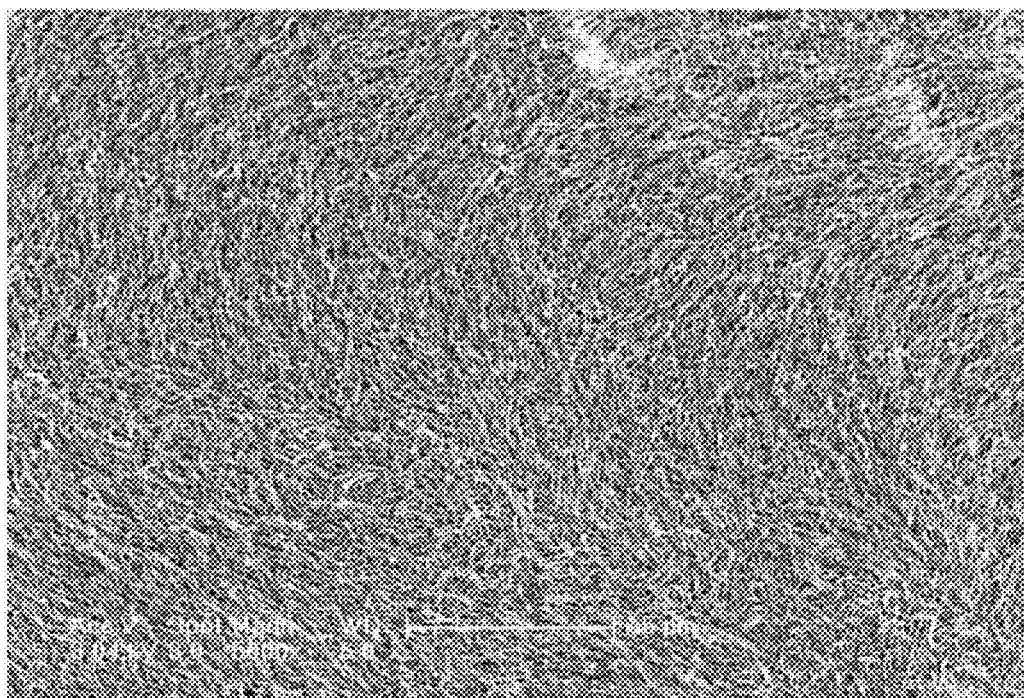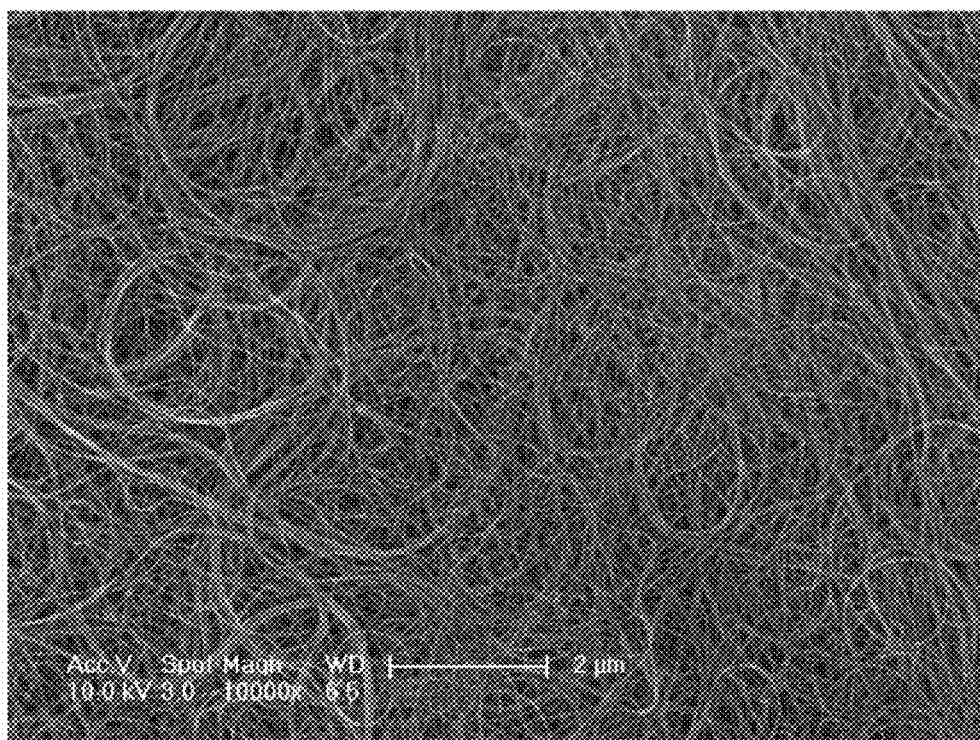(S50), obtaining value of unknown electric potential difference U from the relationship
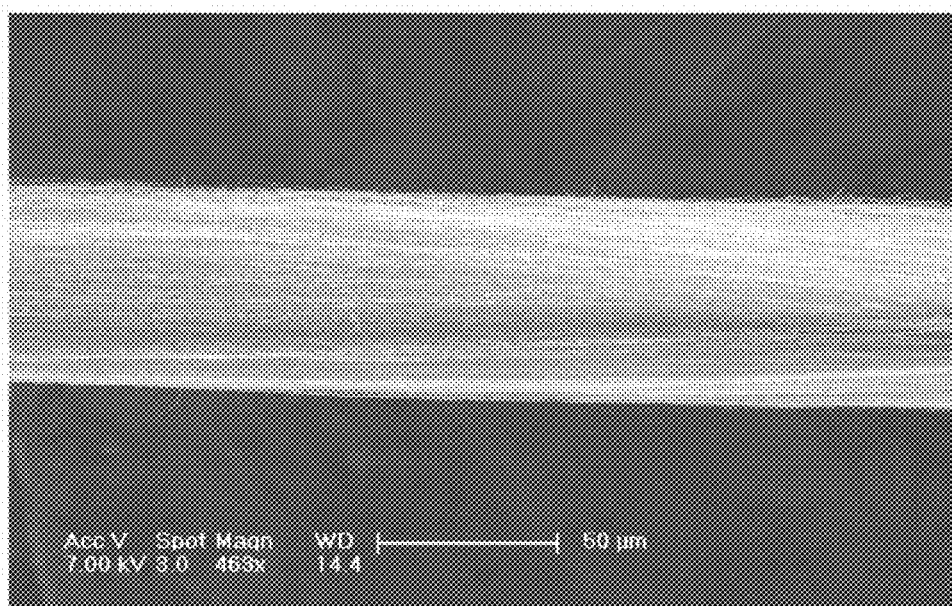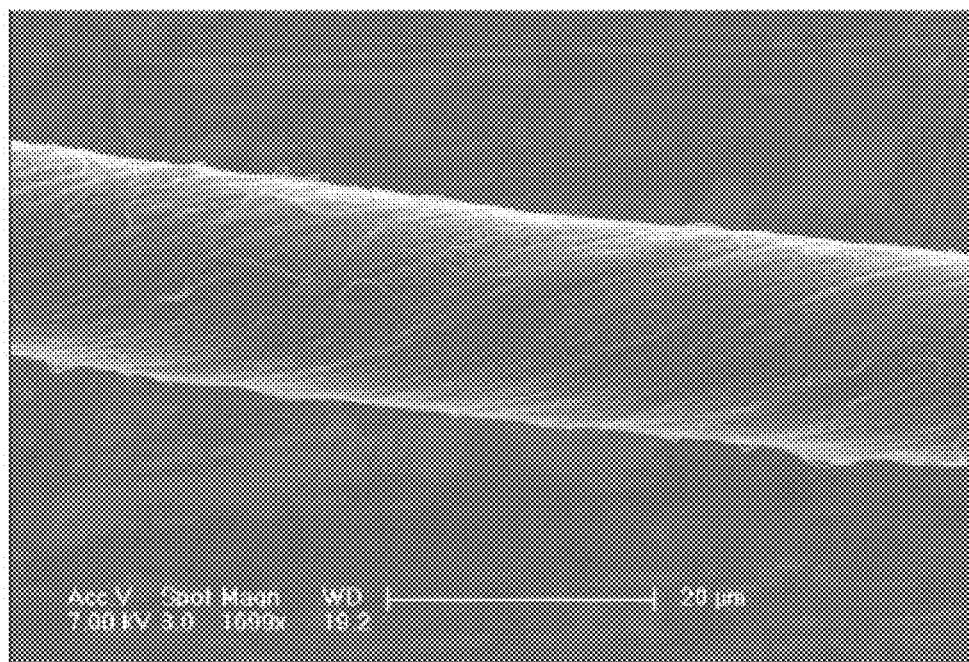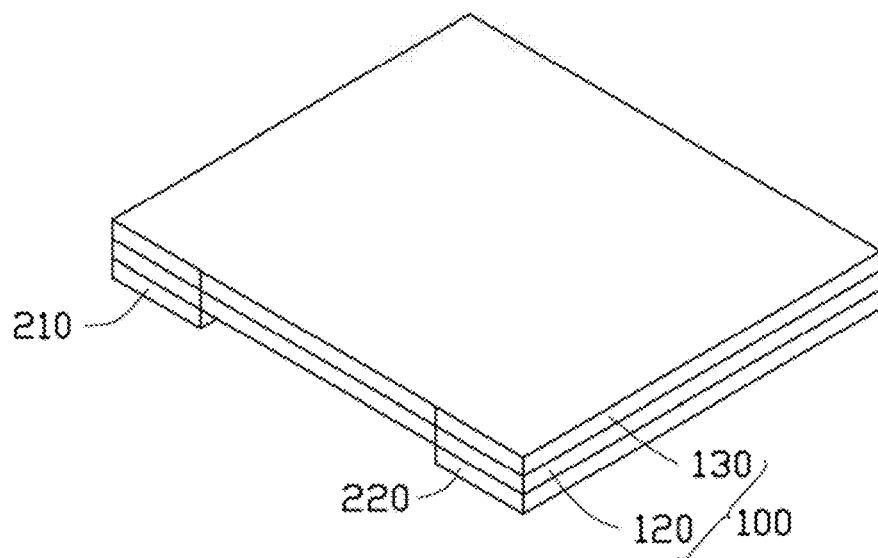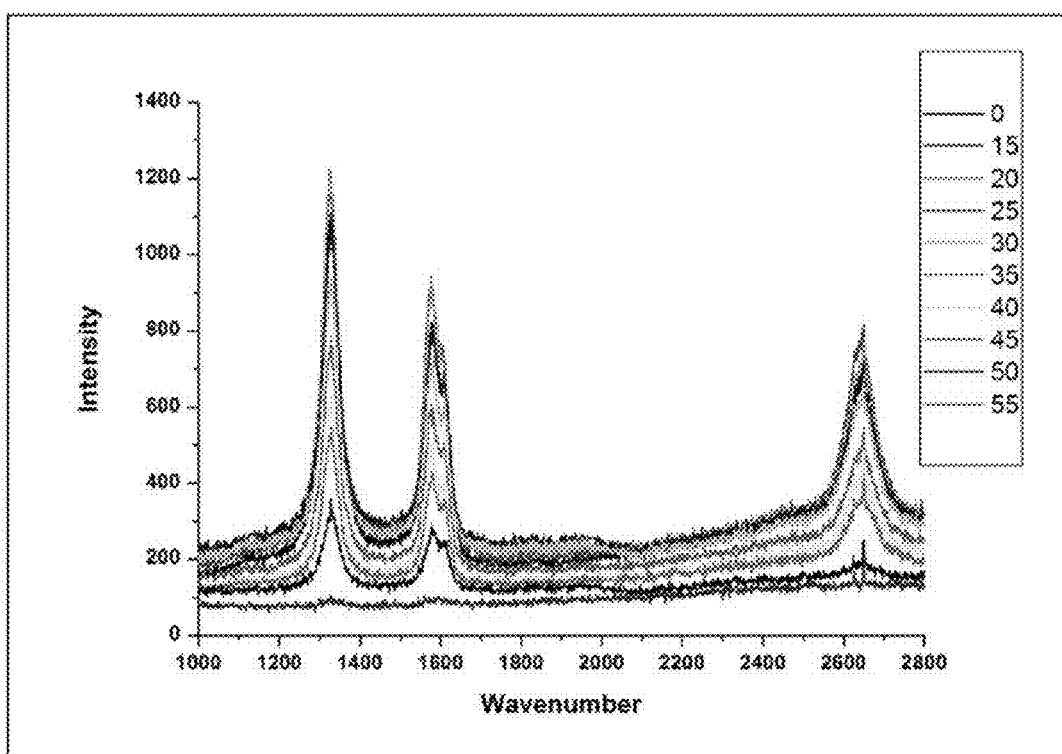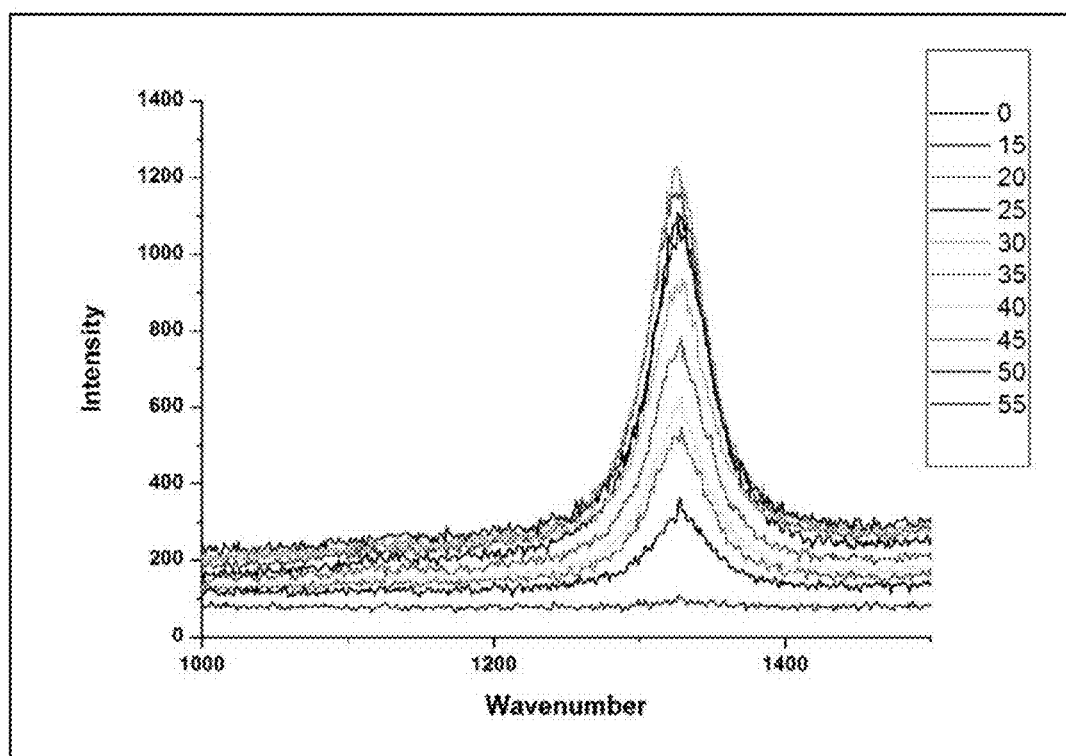
FIG. 1

FIG. 2

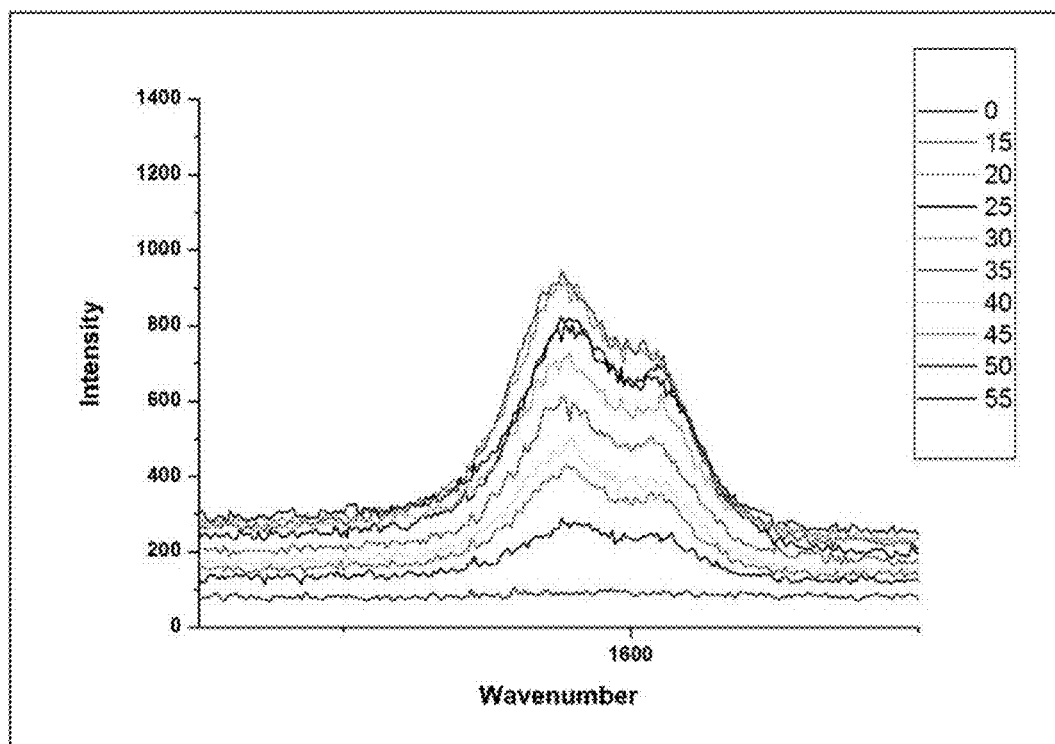FIG. 3

FIG. 4

FIG. 5

FIG. 6

FIG. 7

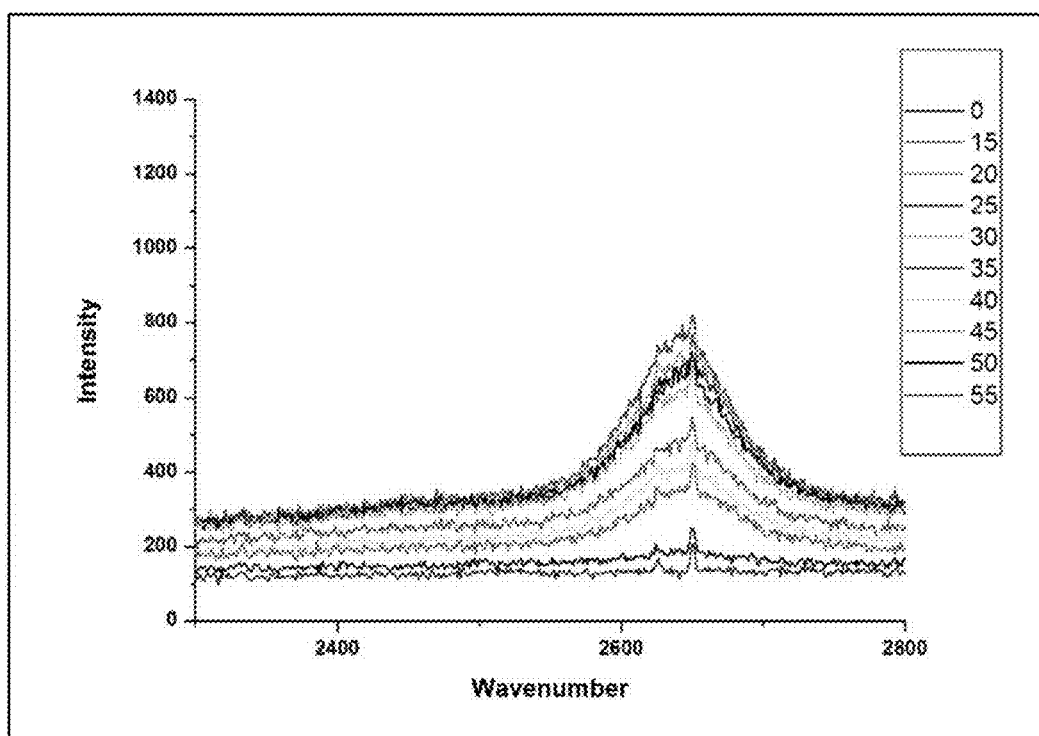FIG. 8

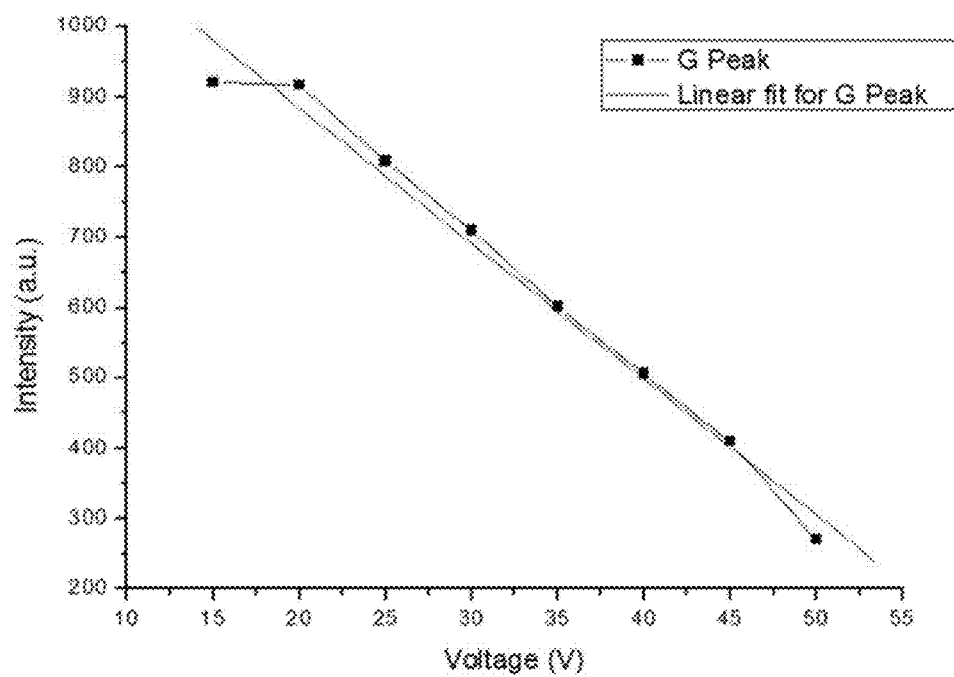FIG. 9

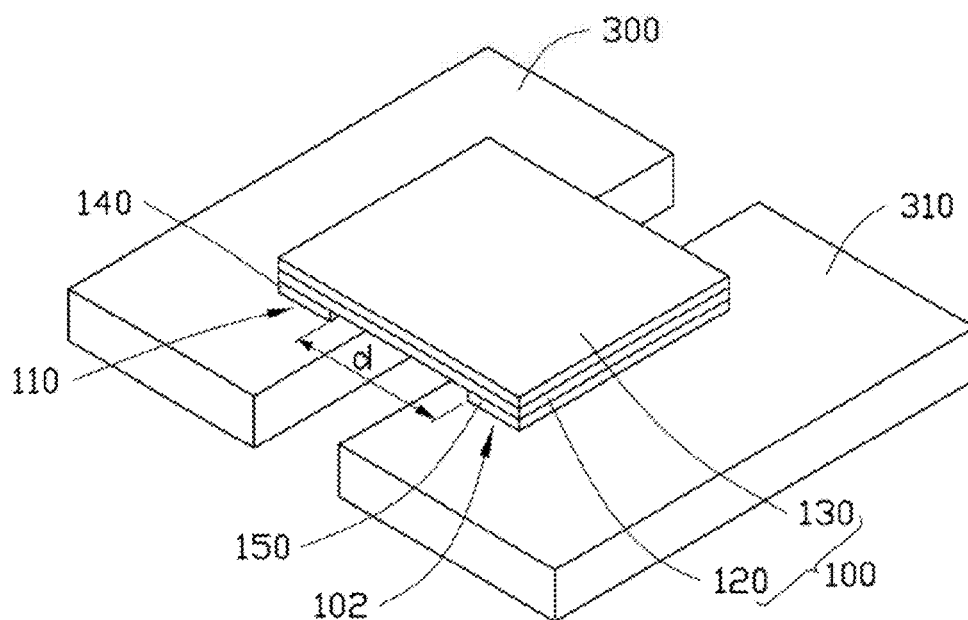FIG. 10

FIG. 11A

FIG. 11B

FIG. 11C

FIG. 11D

FIG. 12

FIG. 13

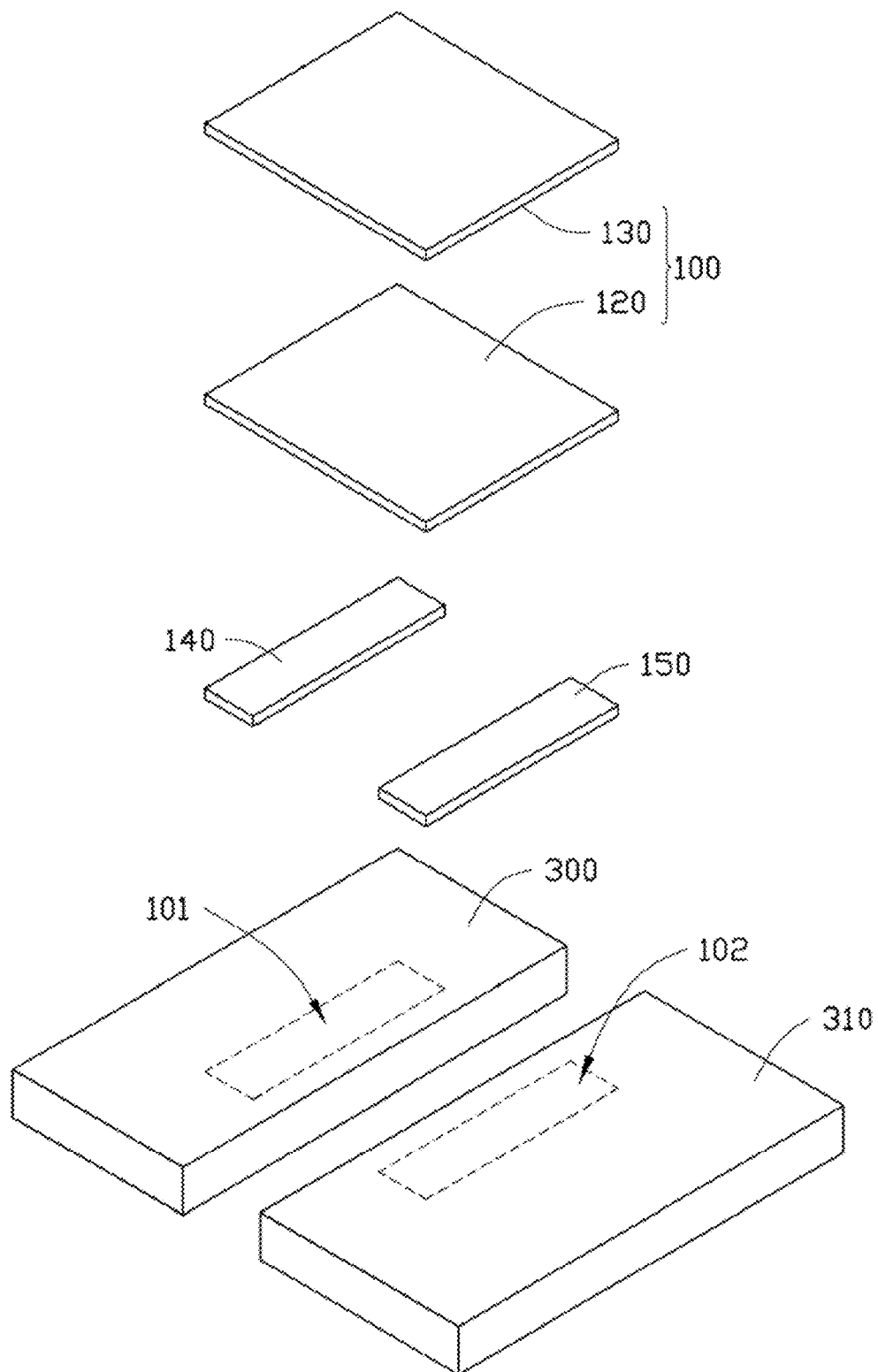FIG. 14

METHOD FOR MEASURING ELECTRIC POTENTIAL DIFFERENCE

This application claims all benefits accruing under 35 U.S.C. §119 from China Patent Application No. 201210582131.6 filed on Dec. 28, 2012 in the China Intellectual Property Office.

BACKGROUND

1. Technical Field

The present disclosure relates to a method for measuring electric potential difference.

2. Discussion of Related Art

Electric potential difference is an important parameter which reflects the electrical properties of an electrical device. The measurement of the electric potential difference of a variety of electrical devices is particularly important.

When the electrical device or a distance needed to be measured between two regions is micro-scaled, such as smaller than 20 micrometers, it is more difficult to measure the electric potential difference between the two regions. One reason is, that measuring instruments in the traditional method are large compared to the distance between two regions to be measured.

What is needed, therefore, is to provide a method for measuring the electric potential difference in the micro-scaled electrical devices or distance.

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the embodiments can be better understood with references to the following drawings. The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the embodiments. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

FIG. **1** shows a flowchart of one embodiment of a method for measuring electric potential difference.

FIG. **2** is a structural schematic view of an embodiment of an electric potential difference measurement apparatus.

FIG. **3** shows an exploded view of the measurement apparatus of FIG. **2**.

FIG. **4** shows a scanning electron microscope (SEM) image of a drawn carbon nanotube film.

FIG. **5** shows a SEM image of a pressed carbon nanotube film including isotropic carbon nanotubes.

FIG. **6** shows a SEM image of a pressed carbon nanotube film including a plurality of carbon nanotubes having a preferred orientation.

FIG. **7** shows a SEM image of a floccule carbon nanotube film.

FIG. **8** shows a SEM image of an untwisted carbon nanotube wire.

FIG. **9** shows a SEM image of a twisted carbon nanotube wire.

FIG. **10** shows a curve representing a relationship between characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU of the carbon nanotube composite layer.

FIGS. **11A-11D** shows a Raman spectrum of the carbon nanotube composite layer under different voltage applied on the carbon nanotube composite layer.

FIG. **12** shows a curve representing a relationship between the characteristic G band frequency value of Raman-spectra and the voltage applied on the carbon nanotube composite layer.

FIG. **13** shows a structural schematic view of another embodiment of an electric potential difference measurement apparatus.

FIG. **14** shows an exploded view of the measurement apparatus of FIG. **13**.

DETAILED DESCRIPTION

The disclosure is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and such references mean at least one.

Referring to FIG. **1**, one embodiment of a method for measuring electric potential difference includes following steps:

(S10), providing an object **110** having a first region **101** and a second region **102** spaced from each other, wherein an unknown electric potential difference U exists between the first region **101** and the second region **102**;

(S20), locating a carbon nanotube composite layer **100** on the object **110** and electrically connecting two opposite ends of the carbon nanotube composite layer **100** to the first region **101** and the second region **102**;

(S30), measuring a characteristic band frequency value Y* of Raman-spectra of the carbon nanotube composite layer **100** under the unknown electric potential difference U;

(S40), obtaining a relationship between a characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU between the first region **101** and the second region **102**; and

(S50), obtaining value of unknown electric potential difference U from the relationship.

In step (S10), the shape of the object **110** can be circular, rectangular, triangular, or other geometric. A distance d between the first region **101** and the second region ranges from about 1 micrometer to about 10 centimeters. In one embodiment, the distance d ranges from about 1 micrometer to about 20 micrometers.

In step (S20), the carbon nanotube composite layer **100** is electrically connected to the first region **101** and the second region **102**. In one embodiment, the carbon nanotube composite layer **100** includes a first end and a second end opposite to the first end. The first end is electrically connected to the first region **101**, and the second end is electrically connected to the second region **102**.

A portion of the carbon nanotube composite layer **100** between the first region **101** and the second region **102** is spaced from the object **110**. The first end can be electrically connected to the first region **101** via a first electrode **140** sandwiched between the object **110** and the carbon nanotube composite layer **100**. The second end can be electrically connected to the second region **102** via a second electrode **150** sandwiched between the object **110** and the carbon nanotube composite layer **100**. The first electrode **140** is located in the first region **101**, and the second electrode **150** is located in the second region **102**. The first electrode **140** and the second electrode **150** can totally cover the first region **101** and the second region **102** respectively.

The first electrode **140** and the second electrode **150** can be bar-shape, rod-shaped, or other geometric. The material of the first electrode **140** and the second electrode **150** can be metal, conductive polymer, conductive glue, metallic carbon nanotube, or Indium tin oxide (ITO). The first electrode **140** and the second electrode **150** can be formed on first region **101** and the second region **102** respectively via

chemical vapor deposition method, physical vapor deposition method, vacuum vapor deposition method, magnetron sputtering method or coating method. In one embodiment, the first electrode **140** and the second electrode **150** are bar-shaped, and coated on the object **110** via conductive glue.

It is can be understood that, the carbon nanotube composite layer **100** can be located on the object **110**, and the first end and the second end of the carbon nanotube composite layer **100** can be directly located on the first region **101** and the second region **102** respectively. The first region **101** and the second region **102** is smooth, and the carbon nanotube composite layer **100** can be tightly attached on the first region **101** and the second region **102**. A part of the carbon nanotube composite layer **100** between the first region **101** and the second region **102** is spaced from the object by an insulating layer (not shown). Thus the first electrode **140** and the second electrode **150** can be omitted.

The portion of the carbon nanotube composite layer **100** between the first region **101** and the second region **102** can be spaced from the object **110** via an insulating layer (not shown) sandwiched between them. In one embodiment, the carbon nanotube composite layer **100** is suspended above the object **110** through the first electrode **140** and the second electrode **150**. That is, the portion of the carbon nanotube composite layer **100** between the first electrode **140** and the second electrode **150** is suspended. The carbon nanotube composite layer **100** comprises a plurality of carbon nanotubes uniformly dispersed in the carbon nanotube composite layer, and the plurality of carbon nanotubes forms a conductive network, thus the electric current is uniformly dispersed in the carbon nanotube composite layer **100**.

The carbon nanotube composite layer **100** includes a carbon nanotube layer **120** and a metal layer **130**, located on the carbon nanotube layer **120**. The metal layer **130** includes a plurality of metal particles and can be a continuously layered-structure. The carbon nanotube layer **120** includes a plurality of carbon nanotubes. In one embodiment, the carbon nanotube layer **120** consists of the plurality of carbon nanotubes. The carbon nanotube layer **120** includes a first surface adjacent to the object **110**, and a second surface opposite to the first surface. The metal layer **130** consists of the plurality of metal particles and is located on the second surface of the carbon nanotube layer **120**. At least part of the plurality of carbon nanotubes are coated with the metal layer **130**.

The carbon nanotube layer **120** is a continuously layered-structure. A thickness of the carbon nanotube layer **120** ranges from about 0.5 nanometers to about 1 millimeter. The carbon nanotube layer **120** is a freestanding structure. The term "freestanding structure" means that the carbon nanotube layer **120** can sustain the weight of itself when it is hoisted by a portion thereof without any significant damage to its structural integrity. Thus, the carbon nanotube layer **120** can be suspended by two spaced supports. The carbon nanotube layer **120** includes a plurality of carbon nanotubes parallel with the surface of the carbon nanotube layer **120**. The carbon nanotubes in the carbon nanotube layer **120** can be single-walled, double-walled, or multi-walled carbon nanotubes. In one embodiment, the carbon nanotube layer **120** can be a substantially pure structure of carbon nanotubes. The plurality of carbon nanotubes are joined by van der Waals force. The length and diameter of the carbon nanotubes can be selected according to need.

The carbon nanotube layer **120** can include at least one carbon nanotube film, at least one carbon nanotube wire, or combination thereof. In one embodiment, the carbon nano-

tube layer **120** can include a single carbon nanotube film or two or more stacked carbon nanotube films. The carbon nanotube film can be a drawn carbon nanotube film, a floccule carbon nanotube film, or a pressed carbon nanotube film. In another embodiment, the carbon nanotube layer **120** can include a plurality of untwisted carbon nanotube wires or a plurality of twisted wires.

Referring to FIG. **4**, the drawn carbon nanotube film can be drawn from a carbon nanotube array that is able to have a film drawn therefrom. The drawn carbon nanotube film includes a plurality of successive and oriented carbon nanotubes joined end-to-end by van der Waals attractive force therebetween. The drawn carbon nanotube film is a freestanding film. The drawn carbon nanotube film includes a plurality of successively oriented carbon nanotube segments joined end-to-end by van der Waals attractive force therebetween. Each carbon nanotube segment includes a plurality of carbon nanotubes parallel to each other, and combined by van der Waals attractive force therebetween. Some variations can occur in the drawn carbon nanotube film. The carbon nanotubes in the drawn carbon nanotube film are oriented along a preferred orientation. The drawn carbon nanotube film can be treated with an organic solvent to increase the mechanical strength and toughness and reduce the coefficient of friction of the drawn carbon nanotube film. A thickness of the drawn carbon nanotube film can range from about 0.5 nm to about 100 μm. While the drawn carbon nanotube film located on the object **110**, the plurality of carbon nanotubes can be parallel with the surface of the object **110**.

The carbon nanotube layer **120** can include at least two stacked drawn carbon nanotube films. In other embodiments, the carbon nanotube layer **120** can include two or more coplanar drawn carbon nanotube films, and can include layers of coplanar drawn carbon nanotube films. Additionally, when the carbon nanotubes in the drawn carbon nanotube film are aligned along one preferred orientation (e.g., the drawn carbon nanotube film), an angle can exist between the orientation of carbon nanotubes in adjacent films, whether stacked or adjacent. Adjacent drawn carbon nanotube films can be combined by only the van der Waals attractive force therebetween. An angle between the aligned directions of the carbon nanotubes in two adjacent drawn carbon nanotube films can range from about 0 degrees to about 90 degrees. When the angle between the aligned directions of the carbon nanotubes in adjacent stacked drawn carbon nanotube films is larger than 0 degrees. In one embodiment, the carbon nanotube layer **120** is shown with the angle between the aligned directions of the carbon nanotubes in adjacent stacked drawn carbon nanotube films is 90 degrees. Stacking the drawn carbon nanotube films will also add to the structural integrity of the carbon nanotube layer **120**.

Referring to FIGS. **5-6**, the pressed carbon nanotube film can include a plurality of carbon nanotubes. The plurality of carbon nanotubes in the carbon nanotube film can be overlapped with each other. The adjacent carbon nanotubes are combined and attracted by van der Waals attractive force, thereby forming a free-standing structure. The carbon nanotube film can be formed by pressing a carbon nanotube array. An angle between a primary alignment direction of the carbon nanotubes and a base of the pressed carbon nanotube film such that the angle is in an approximate range from 0° to approximately 15°. The angle is closely related to pressure applied to the carbon nanotube array. The greater the pressure, the smaller the angle. The plurality of carbon nanotubes in the pressed carbon nanotube film can parallel

to the surface of the pressed carbon nanotube film. A length and a width of the pressed carbon nanotube film can be arbitrarily set as desired. The plurality of carbon nanotubes in the pressed carbon nanotube film are arranged isotropically, arranged along a same direction or arranged along different directions according to the pressed direction. Referring to FIG. **5**, the plurality of carbon nanotubes are overlapped with each other and substantially oriented along the same direction. Referring to FIG. **6**, the plurality of carbon nanotubes are overlapped with each other and oriented along different directions.

Referring to FIG. **7**, the floccule carbon nanotube film can include a plurality of carbon nanotubes entangled with each other to form a carbon nanotube floccule structure. A length of the carbon nanotubes is above about 10 microns. The adjacent carbon nanotubes are combined and entangled by van der Waals attractive force therebetween, thereby forming an entangled structure/microporous structure. Further, the carbon nanotube film is isotropic. It is understood that the carbon nanotube film is very microporous. Sizes of the micropores are less than about 10 micrometers. Length and width of the carbon nanotube film are not limited. In the present embodiment, the carbon nanotube film includes a plurality of long, curved, disordered carbon nanotubes entangled with each other.

The carbon nanotube film can be directly attached on the first region **101** and the second region **102**, or the first electrode **140** and the second electrode **150**. Furthermore, the carbon nanotube film can be treated with an organic solvent after being placed on the object **110**. Specifically, the organic solvent can be dipped onto the carbon nanotube layer which is located in the first region **101** and the second region **102**. The organic solvent can be volatile, such as ethanol, methanol, acetone, dichloromethane, chloroform, or mixtures thereof. In one embodiment, the organic solvent is ethanol.

Referring to FIGS. **8-9**, the carbon nanotube layer **120** can also include a plurality of carbon nanotube wires intersected with each other to form a layered-structure. The carbon nanotube wire includes a plurality of carbon nanotubes aligned along an axial direction of the carbon nanotube wire. The plurality of carbon nanotube wire intersects with each other to form a conductive web. Referring to FIG. **8**, the carbon nanotube wire can be untwisted. The untwisted carbon nanotube wire includes a plurality of carbon nanotubes substantially oriented along a same direction (i.e., a direction along the length of the untwisted carbon nanotube wire). The carbon nanotubes are parallel to the axis of the untwisted carbon nanotube wire. More specifically, the untwisted carbon nanotube wire includes a plurality of successive carbon nanotube segments joined end to end by van der Waals attractive force therebetween. Each carbon nanotube segment includes a plurality of carbon nanotubes substantially parallel to each other, and combined by van der Waals attractive force therebetween. The carbon nanotube segments can vary in width, thickness, uniformity and shape. Length of the untwisted carbon nanotube wire can be arbitrarily set as desired. A diameter of the untwisted carbon nanotube wire ranges from about 0.5 nm to about 100 μm. Referring to FIG. **9**, the twisted carbon nanotube wire can be formed by twisting a drawn carbon nanotube film using a mechanical force to turn the two ends of the drawn carbon nanotube film in opposite directions. The twisted carbon nanotube wire includes a plurality of carbon nanotubes helically oriented around the axial direction of the twisted carbon nanotube wire. More specifically, the twisted carbon nanotube wire includes a plurality of successive carbon

nanotube segments joined end to end by van der Waals attractive force therebetween. Each carbon nanotube segment includes a plurality of carbon nanotubes parallel to each other, and combined by van der Waals attractive force therebetween. Length of the carbon nanotube wire can be set as desired. A diameter of the twisted carbon nanotube wire can be from about 0.5 nm to about 100 μm. Further, the twisted carbon nanotube wire can be treated with a volatile organic solvent after being twisted. After being soaked by the organic solvent, the adjacent paralleled carbon nanotubes in the twisted carbon nanotube wire will bundle together, due to the surface tension of the organic solvent when the organic solvent volatilizing. The specific surface area of the twisted carbon nanotube wire will decrease, while the density and strength of the twisted carbon nanotube wire will be increased.

The metal layer **130** includes a plurality of metallic particles located on the surface of the carbon nanotube layer **120** away from the object **110**. The metal layer **130** shields the carbon nanotube layer **120** from being irradiated by the laser. A material of the metal layer **130** can be nickel, iron, chromium or other metals. In one embodiment, material of the metal layer **130** is nickel. A thickness of the metal layer **130** ranges from about 5 nanometers to about 50 nanometers, such as 10 nanometers, 20 nanometers. The metal layer **130** can be deposited on the carbon nanotube layer **120** via chemical vapor deposition method, physical vapor deposition method, vacuum deposition method or magnetron sputtering method.

In the step (S**30**), the characteristic band frequency value of Raman-spectra of the carbon nanotube composite layer **100** can be obtained via a Raman spectrometer. A Raman-laser emitted by the Raman spectrometer is focused on the carbon nanotube composite layer **100**. In detail, the Raman-laser is focused on the metal layer **130** of the carbon nanotube composite layer **100**. The Raman-spectra of the carbon nanotube composite layer **100** includes a plurality of peaks. The higher peaks such as peak G, peak D, and the peak 2D can be configured as the characteristic band frequency value of Raman-spectra of the carbon nanotube composite layer **100**. The peak G is the highest peak in the Raman-spectra of the carbon nanotube composite layer **100**. In one embodiment, the peak G is configured as the characteristic band frequency value of Raman-spectra of the carbon nanotube composite layer **100**.

While an electric potential difference exists between the first region **101** and the second region **102**, an electric current will flows in the carbon nanotube composite layer **100**. Thus temperature of the carbon nanotube composite layer **100** will be raised into a determined temperature, and the characteristic band frequency value of Raman-spectra of the carbon nanotube composite layer **100** will be accordingly changed. Furthermore, the characteristic band frequency value of Raman-spectra of the carbon nanotube composite layer **100** varies linearly with its temperature. Therefore, the characteristic band frequency value of Raman-spectra varies linear with the electric potential difference between the first region **101** and the second region **102**. Thus the electric potential difference between the first region **101** and the second region **102** can be calculated out by measuring the characteristic band frequency value of Raman-spectra.

The Raman-laser is focused on the portion of the carbon nanotube composite layer **100** suspended between the first region **101** and the second region **102**. Since the resolution ability of the Raman-laser can reach to 1 micrometer so that each point of suspended part of the carbon nanotube com-

posite layer **100** having a length less than 20 micrometers can be accurately measured. Furthermore, the Raman-laser can be focused on different points of the carbon nanotube composite layer **100** to get a plurality of characteristics band frequency value of the carbon nanotube layer **120**. Thus the characteristic band frequency value of the carbon nanotube composite layer **100** can be defined as the average value of the plurality of characteristic band frequency value. In one embodiment, three different points of the carbon nanotube composite layer can be focused on.

Referring to FIG. **10**, in the step (S40), the relationship between the characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU of the carbon nanotube composite layer **100** can be obtained by following steps:

(S401), providing a carbon nanotube composite layer **200** which is same as the carbon nanotube composite layer **100**;

(S402), locating a third electrode **210** and a fourth electrode **220** electrically connected to the carbon nanotube composite layer **200**, wherein the third electrode **210** and the fourth electrode **220** are spaced from each other;

(S403), obtaining a plurality of characteristic band frequency value Y' of Raman-spectra of the carbon nanotube composite layer **200** by applying a plurality of predetermined voltage ΔU' between the third electrode **210** and the fourth electrode **220**; and

(S404), obtaining the relationship as Y=a·ΔU+b by fitting the plurality of characteristic band frequency value Y' and the plurality of predetermined voltage ΔU' to a curve, wherein a and b are constant value respectively.

In step (S401), the carbon nanotube composite layer **200** is same as the carbon nanotube composite layer **100**, means that the characteristic of the carbon nanotube composite layer **200** is same as the carbon nanotube composite layer **100**, such as the characteristic band frequency value of Raman-spectra. The carbon nanotube composite layer **200** and the carbon nanotube layer **120** can be divided from one carbon nanotube composite layer. Because the carbon nanotube composite layer **100** is attached on the object **120** and applied with the determined electric potential difference, thus it is not convenient directly obtain the relationship between the characteristic band frequency value Y of Raman-spectra and various electric potential difference ΔU. However, because the characteristic of the carbon nanotube composite layer **200** is same as the carbon nanotube composite layer **100**, thus the relationship between the characteristic band frequency value of Raman-spectra and various electric potential difference of carbon nanotube composite layer **100** can be defined as the relationship of the carbon nanotube composite layer **200**.

In step (S402), the third electrode **210** and the fourth electrode **220** are spaced from each other. A distance between the third electrode **210** and the fourth electrode **220** is greater than 1 micrometer. In one embodiment, the distance between the third electrode **210** and the fourth electrode **220** ranges from about 10 micrometers to about 10 centimeters. In one embodiment, the distance is about 3 centimeters.

In the step (S403), the third electrode **210** and the fourth electrode **220** are electrically connected to a power supply device (not shown). The power supply device supplies the plurality of predetermined voltage between the third electrode **210** and the fourth electrode **220**. Referring to FIGS. **11A-11D**, the plurality of characteristic band frequency value Y of Raman-spectra under the plurality of predetermined voltage can be measured by the Raman-spectrometer.

In step (S404), the method for fitting the plurality of characteristic band frequency value Y' and the plurality of predetermined voltage ΔU' can be with the use of linear regression, non-linear regression, or with a spline function. In one embodiment, the plurality of characteristic band frequency value Y' and the plurality of predetermined voltage ΔU' is fit by linear regression and a straight line is obtained as shown in FIG. **12**. The straight line represents the characteristic band frequency value Y dependence of the predetermined voltage ΔU, and the straight line is represented as a formula Y=a·ΔU+b, and a, b are constants. In one embodiment, the relationship between the characteristic band frequency value Y and the predetermined voltage ΔU is shown as Y=1271.2−19.3×ΔU.

In step (S50), the unknown electric potential difference U between the first region **101** and the second region **102** can be obtained through the relationship Y=a·ΔU+b. From the relationship Y=a·ΔU+b, the electric potential difference ΔU can be deduced as ΔU=(Y−b)/a. Therefore, for the characteristic band frequency value Y*, the unknown electric potential difference U between the first region **101** and the second region **102** can be calculated by U=(Y*−b)/a.

Furthermore, the carbon nanotube composite layer **100** can be easily removed from the object **110**. The carbon nanotube composite layer **100** can be removed by washing with water, laser etching, or peeled off with a pliers without damaging the object **110**. The method is suitable for measuring the electric potential difference under micro-sized distance.

Referring to FIGS. **13-14**, another embodiment of a method for measuring electric potential difference between two spaced objects includes following steps:

(S10), providing a first object **300** and a second object **310** spaced from the first object **300**, wherein an unknown electric potential difference U exists between the first object **300** and the second object **310**;

(S20), locating a carbon nanotube composite layer **100** electrically connected to the first object **300** and the second object **310**;

(S30), measuring the characteristic band frequency value Y* of Raman-spectra of the carbon nanotube composite layer **100** under the unknown electric potential difference U;

(S40), obtaining a relationship between the characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU between the first object **300** and the second object **310**; and

(S50), obtaining value of unknown electric potential difference U from the relationship.

In the step (S20), the carbon nanotube composite layer **100** is suspended on the first object **300** and the second object **310**. The carbon nanotube composite layer **100** includes a first end and a second end electrically connected to the first end. The first end is attached on the first object **300**, and the second end is attached on the second object **310**. A part of the carbon nanotube composite layer **100** between the first end and the second end is suspended.

Depending on the embodiments, certain of the steps described may be removed, others may be added, and the sequence of steps may be altered. It is also to be understood that the description and the claims drawn to a method may include some indication in reference to certain steps. However, the indication used is only to be viewed for identification purposes and not as a suggestion as to an order for the steps.

It is to be understood, however, that even though numerous characteristics and advantages of the present embodiments have been set forth in the foregoing description,

together with details of the structures and functions of the embodiments, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the disclosure.

What is claimed is:

1. A method for measuring electric potential difference, the method comprising:

providing an object comprising a first region and a second region spaced from the first region, wherein an unknown electric potential difference U exists between the first region and the second region;

placing a first carbon nanotube composite layer on the object, wherein the first carbon nanotube composite layer is electrically connected to the first region and the second region;

irradiating the first carbon nanotube composite layer with a Raman-laser to measure a characteristic band frequency value Y* of Raman-spectra of the first carbon nanotube composite layer under the unknown electric potential difference U; and

obtaining a value of the unknown electric potential difference U from formula U=(Y*−b)/a, wherein a and b are two constants.

2. The method of claim 1, wherein a part of the first carbon nanotube composite layer between the first region and the second region is spaced from the object.

3. The method of claim 2, wherein the part of the first carbon nanotube composite layer between the first region and the second region is suspended above the object.

4. The method of claim 1, further comprising locating a first electrode on the first region and locating a second electrode on the second region before locating the first carbon nanotube composite layer.

5. The method of claim 4, wherein the first carbon nanotube composite layer is electrically connected to the first electrode and the second electrode and suspended on the object through the first electrode and the second electrode.

6. The method of claim 5, wherein the first carbon nanotube composite layer comprises a first end located on the first electrode, and a second end located on the second electrode.

7. The method of claim 1, wherein the first carbon nanotube composite layer comprises a plurality of carbon nanotubes uniformly dispersed in the first carbon nanotube composite layer, and the plurality of the carbon nanotubes forms a conductive network.

8. The method of claim 1, wherein the first carbon nanotube composite layer comprises a carbon nanotube layer and a metal layer located on the carbon nanotube layer.

9. The method of claim 8, wherein the carbon nanotube layer is a free standing structure, and the metal layer is coated on the carbon nanotube layer.

10. The method of claim 9, wherein the metal layer comprises a plurality of metallic particles coated on a surface of the carbon nanotube layer away from the object.

11. The method of claim 8, wherein the Raman-laser is irradiated on the metal layer, and the carbon nanotube layer is shielded from the Raman-laser by the metal layer.

12. The method of claim 8, wherein a thickness of the metal layer ranges from about 5 nanometers to about 20 nanometers.

13. The method of claim 1, wherein Raman-spectra of the first carbon nanotube composite layer comprises a plurality of peaks, and the characteristic band frequency value Y* of Raman-spectra of the first carbon nanotube composite layer is obtained from an highest peak G in the plurality of peaks.

14. The method of claim 1, further comprising obtaining a relationship between characteristic band frequency value Y of Raman-spectra and an electric potential difference ΔU between the first region and the second region of the first carbon nanotube composite layer.

15. The method of claim 14, wherein the relationship between the characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU between the first region and the second region comprising following substeps:

providing a second carbon nanotube composite layer which is same as the first carbon nanotube composite layer;

locating a third electrode and a fourth electrode electrically connected to the second carbon nanotube composite layer, wherein the third electrode and the fourth electrode are spaced from each other;

obtaining a plurality of characteristic band frequency values Y′ of Raman-spectra of the second carbon nanotube composite layer by applying a plurality of predetermined voltages ΔU′ between the third electrode and the fourth electrode; and

obtaining the relationship between the characteristic band frequency value Y and the predetermined voltage ΔU of the second carbon nanotube composite layer by fitting the plurality of characteristic band frequency value Y′ and plurality of predetermined voltage ΔU′ of the second carbon nanotube composite layer to a straight line, wherein the relationship between the characteristic band frequency value Y and the predetermined voltage ΔU of the first carbon nanotube composite layer is same as relationship between the plurality of characteristic band frequency values Y′ and the plurality of predetermined voltages ΔU′ of the second carbon nanotube composite layer.

16. The method of claim 15, wherein the relationship between the characteristic band frequency value Y and the predetermined voltage ΔU of the second carbon nanotube composite layer satisfy Y=a·ΔU+b.

17. A method for measuring electric potential difference comprising:

providing a first object and a second object spaced from the first object, wherein an unknown electric potential difference U exists between the first object and the second object;

locating a carbon nanotube composite layer electrically connected to the first object and the second object;

irradiating the carbon nanotube composite layer with a Raman-laser to obtain a characteristic band frequency value Y* of Raman-spectra of the carbon nanotube composite layer under the unknown electric potential difference U;

calculating a value of unknown electric potential difference U from a formula U=(Y*−b)/a, wherein a and b are two constants.

18. The method of claim 17, wherein the carbon nanotube composite layer is suspended by the first object and the second object.

19. A method for measuring electric potential difference comprising:

locating a carbon nanotube composite layer electrically connected to a first region and a second region spaced from each other;

getting a characteristic band frequency value Y* of Raman-spectra of the carbon nanotube composite layer by irradiating the carbon nanotube composite layer via a Raman-laser;

obtaining a relationship between a characteristic band frequency value Y of Raman-spectra and an electric potential difference ΔU of the carbon nanotube composite layer, wherein the relationship is obtained by:

providing a second carbon nanotube composite layer which is same as the carbon nanotube composite layer;

placing a third electrode and a fourth electrode on the second carbon nanotube composite layer and electrically connected to the second carbon nanotube composite layer, wherein the third electrode and the fourth electrode are spaced from each other;

obtaining a plurality of characteristic band frequency values Y' of Raman-spectra of the second carbon nanotube composite layer by applying a plurality of predetermined voltages $\Delta U'$ between the third electrode and the fourth electrode; and

fitting the plurality of characteristic band frequency value Y' and plurality of predetermined voltage $\Delta U'$ of the second carbon nanotube composite layer to a straight line, wherein the relationship between the characteristic band frequency value Y and the predetermined voltage ΔU of the first carbon nanotube composite layer is same as relationships between the plurality of characteristic band frequency values Y' and the plurality of predetermined voltages $\Delta U'$ of the second carbon nanotube composite layer;

and

obtaining a value of an unknown electric potential difference U applied between the first region and the second region by substituting Y* for Y through the relationship between the characteristic band frequency value Y of Raman-spectra and the electric potential difference ΔU.

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